Georgia Institute of Technology
STATE ENGINEERING EXPERIMENT STATION
Atlanta, Georgia

SPECIAL REPORT NO. 1

PROJECT NO. 168

ANALYTICAL STUDY OF THE SAMPLING AND GRADING OF FARMERS' STOCK PEANUTS

Prepared for

STATE ENGINEERING EXPERIMENT STATION
and
GEORGIA EXPERIMENT STATION

By

JOSEPH J. MODER, JR.

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FOREWORD

This special report covers a portion of the work on Project 168, "Industrial Engineering Survey of the Peanut Shelling Industry." The research reported herein was supported by funds provided by the Board of Regents, University System of Georgia, the Georgia-Florida-Alabama Peanut Association, Camilla, Georgia, and by an equal amount of funds authorized under Title II of the Research and Marketing Act of 1946. The work was conducted by the State Engineering Experiment Station of the Georgia Institute of Technology, Atlanta, Georgia. The project is conducted in cooperation with the Department of Agricultural Economics, Georgia Experiment Station, Experiment, Georgia, Project RM:C-411, ES-3. Experimental and field data were obtained from Mr. H. M. Riley, Federal Supervisor of the Federal-State Inspection Service.

Comments and suggestions from individual members of the peanut industry have been helpful and will be appreciated.

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I. SUMMARY OF THE RECOMMENDATIONS FOR PEANUT GRADING

Observations and conversations about peanut grading indicate that the peanut seller has gone through a period of "training in peanut marketing." This training has literally closed the door to the old method of peanut grading which, according to most people, was more satisfactory than the precision point system now used. It seems that the precision point system is here to stay; if so, it should be made workable. This method is definitely a sound basis for pricing peanuts. However, over the past few years the peanut seller has been literally forced to take advantage of the improper and inadequate sampling procedure it employs.

This "training in peanut marketing" should continue but should be directed along constructive lines. This can be accomplished by the following steps:

(1) Discourage and eventually eliminate "scientific loading" of peanuts by installing a sound sampling procedure which renders this practice ineffective. This will require the unloading and automatic sampling of the entire load of peanuts.

(2) Discourage and eliminate "shopping around" by adopting an adequate size sample for analysis. This will require approximately a two-pound sample. Semi-automatic grading machinery will be necessary to handle this size sample at a reasonable cost and in a reasonable length of time.

(3) Encourage the marketing of cleaner peanuts by requiring precleaning before marketing peanut loads containing over five per cent foreign material. This will require extensive installation of low cost, high capacity precleaning equipment.

(4) Formulate a peanut buying program which makes this scheme workable in the field.

II. INTRODUCTION

An analysis of the present method of grading farmers' stock peanuts was made as a part of an over-all industrial engineering study of the peanut shelling industry. Emphasis was placed on this phase of the marketing function because a preliminary analysis indicated that it is more influential on farmer's and sheller's returns than all other marketing operations combined.

This study has conclusively shown that the present system of grading and pricing farmers' stock peanuts is inadequate because it may adversely affect either buyer or seller. It is inadequate because:

(1) The sample for analysis is obtained in a biased manner and is not representative of the entire load of peanuts.

(2) The right to demand regrades coupled with the seller's knowledge and the buyer's ignorance of the true contents of the truck load of peanuts in question, is in effect a bias in favor of the seller.

III. EFFECTS OF THE BIASED SAMPLE

The fact that the sample is obtained in a biased manner is generally accepted and can be attributed to the following causes.

(a) Rocks fall into the sampling tube in greater percentages than are present in the load of peanuts.

(b) Sticks and hay fall into the sampling tube in lesser percentages than are present in the load of peanuts.

(c) Foreign material and high damage or moisture peanuts at the bottom or corners of the truck do not get into the sampling tube at all.

Parts (a) and (b) are borne out by the data of Elliott and Carmichael[1]. These data were plotted as the actual rock content compared with the sampled rock content in Figure 1, and as the actual amount of other foreign material compared with the sampled amount of other foreign material in Figure 2. In these tests, the measured per cent of foreign material was obtained from the original load of peanuts by the present grading procedure, and the actual per cent of foreign material was determined by removing and weighing the various types of foreign material.

Figure 1 shows an excellent straight line relationship between the actual and the measured per cent of rocks with a slope of 0.7. This means that for every 1.0 per cent of rocks measured, only 0.7 per cent of the rocks are actually present in the load of peanuts in the region reached by the sampling tube. Figure 2 shows that the actual per cent of other foreign material is considerably greater than that measured by sampling.

These figures clearly substantiate claims (a) and (b) above and show the futility of trying to determine foreign material by this sampling method--even for peanuts which are not "scientifically loaded."[2]

Part (c) above is somewhat less tangible than (a) and (b). It is obvious that the sampling tube will not sample the material at the bottom of the truck. However, it is difficult to say how widespread is the practice of scientific loading of farmers' stock peanuts. Indications are

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[1] "Machinery for Cleaning Farmers' Stock Peanuts," Georgia State Engineering Experiment Station, July 1, 1951.

[2] "Scientific loading" of peanuts is the name applied to loading which places foreign material, inferior peanuts, or both, at the bottom and corners of the truck in such a manner that the sampling tube will not reach them.

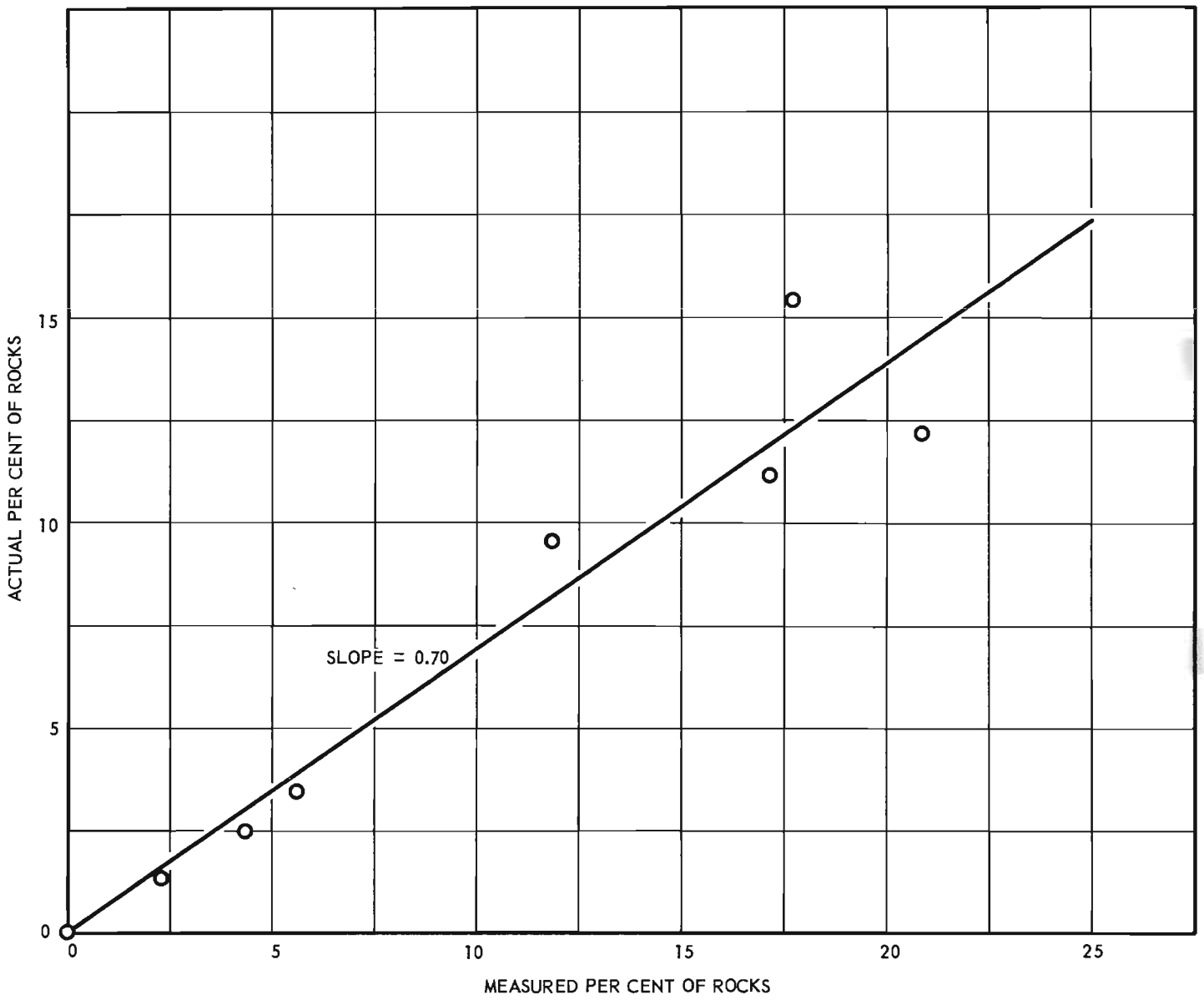

Figure 1. Actual Rock Content Compared with Sampled Rock Content.

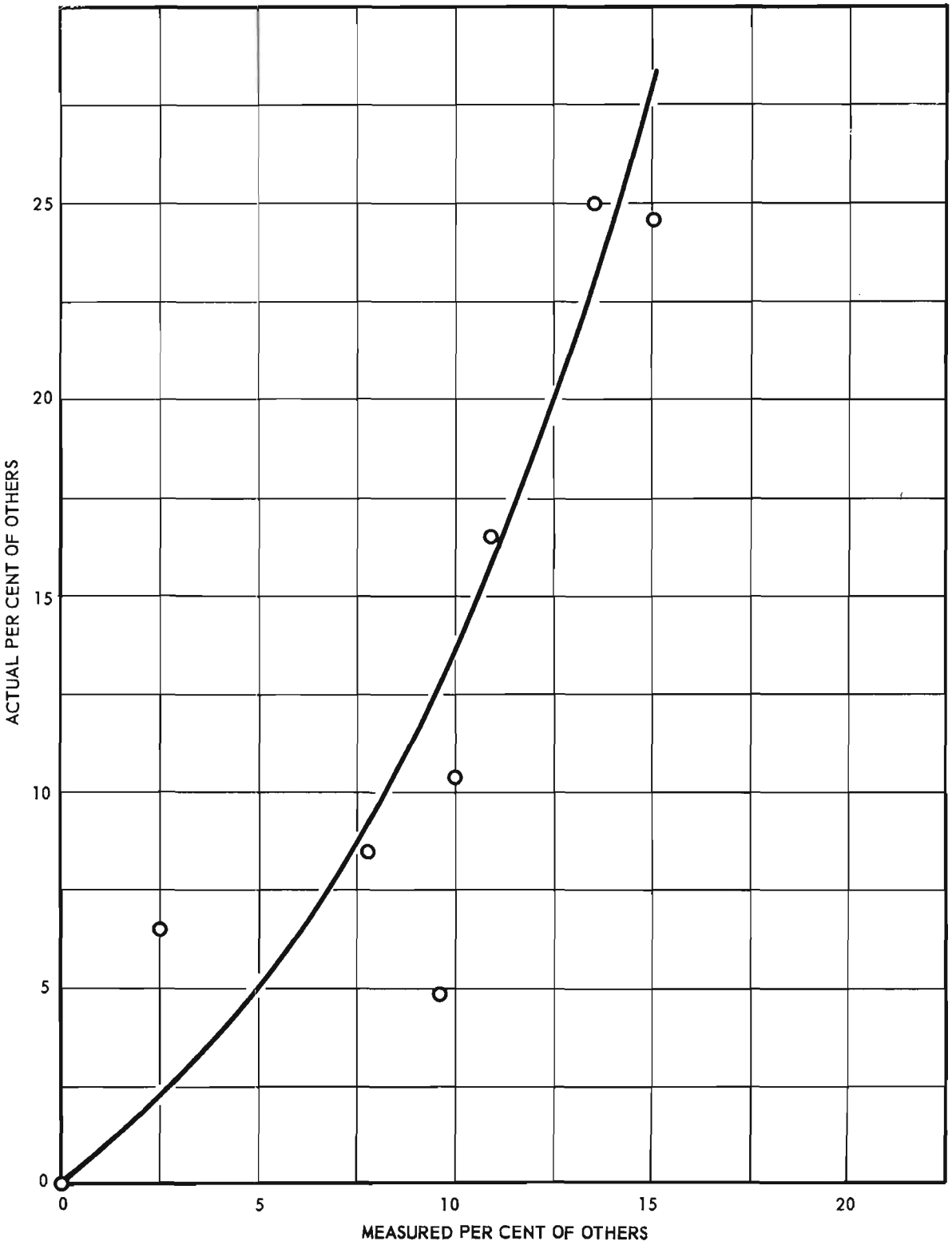

Figure 2. Actual Amount Compared with Sampled Amount of Foreign Material Other than Rock.

that this practice is increasing in the peanut industry because of a combination of many factors. Among these factors are the 1951 adverse weather conditions, the operating details of the 1951 buying procedure, and a gradual training in scientific loading practices. It is a matter of common knowledge that the present marketing conditions encourage the seller to employ scientific loading and to "shop around" to obtain a better price for his load of peanuts.

As a result of the above-mentioned factors, the bucket sample of peanuts selected for analysis is not representative of the entire load of peanuts and in general is unfair to the peanut buyer. It is not unusual to overprice some loads of peanuts by as much as $50 per ton due to these factors. Seemingly there is but one solution to this problem of biased samples. It consists merely of a method of automatically obtaining a representative sample of the entire load of peanuts by unloading and reloading each truck. This sounds like a rather formidable undertaking. However, with suitable equipment it can be accomplished at a reasonable cost. Furthermore, there is a growing emphasis on marketing cleaner peanuts; which is increasing the need for plant pre-cleaning facilities. The automatic sampling equipment can be combined with such pre-cleaning equipment thereby reducing the overall costs of both units.

The basic requirements for this type of automatic sampling are:

(1) Rapid unloading
(2) Rapid elevating
(3) Automatic sampling
(4) Holding bin or bins for reloading

These steps can be accomplished by numerous types of equipment, some of which may already be on hand at many shelling plants. However, a hoist dump pit unloader which can elevate trucks to an angle of 40 degrees is

recommended in conjunction with a bucket elevator of 50 to 60 tons per hour capacity.[3] The automatic sampling device can easily be developed, possibly as a variation of the splitter presently used in grading. A sketch of this basic equipment is shown in Figure 3; as stated above, however, many variations of this design are possible. These might include the use of other types of existing unloading equipment and the addition of pre-cleaning equipment.

A sequence of operations, with their estimated time values, for the operation of the unit shown in Figure 3 are given in Table I below.[4]

TABLE I

SEQUENCE OF OPERATIONS FOR UNLOADING AND AUTOMATIC SAMPLING OPERATION

Operation	Time (Minutes)
(1) Drive truck into place	0.50
(2) Delay time	0.30
(3) Remove tail gate	0.80
(4) Delay time	0.30
(5) Hoist truck	1.00
(6) Delay time	0.30
(7) Lower truck	0.35
(8) Delay time	0.30
(9) Replace tail gate	0.50
(10) Delay time	0.30
(11) Drive truck out	0.35
Total Time (1) - (11)	5.00

[3] An analysis of the various methods of unloading peanuts has shown that the hoist dump pit unloader which elevates to at least 40 degrees is the most rapid and economical method of unloading farmers' stock peanuts. This method is further recommended here because it will hold peanut breakage to a minimum. This is an important factor since it will affect the peanut grade.

[4] These time values are average values obtained from approximately 60 time studies on unloading farmers' stock peanuts.

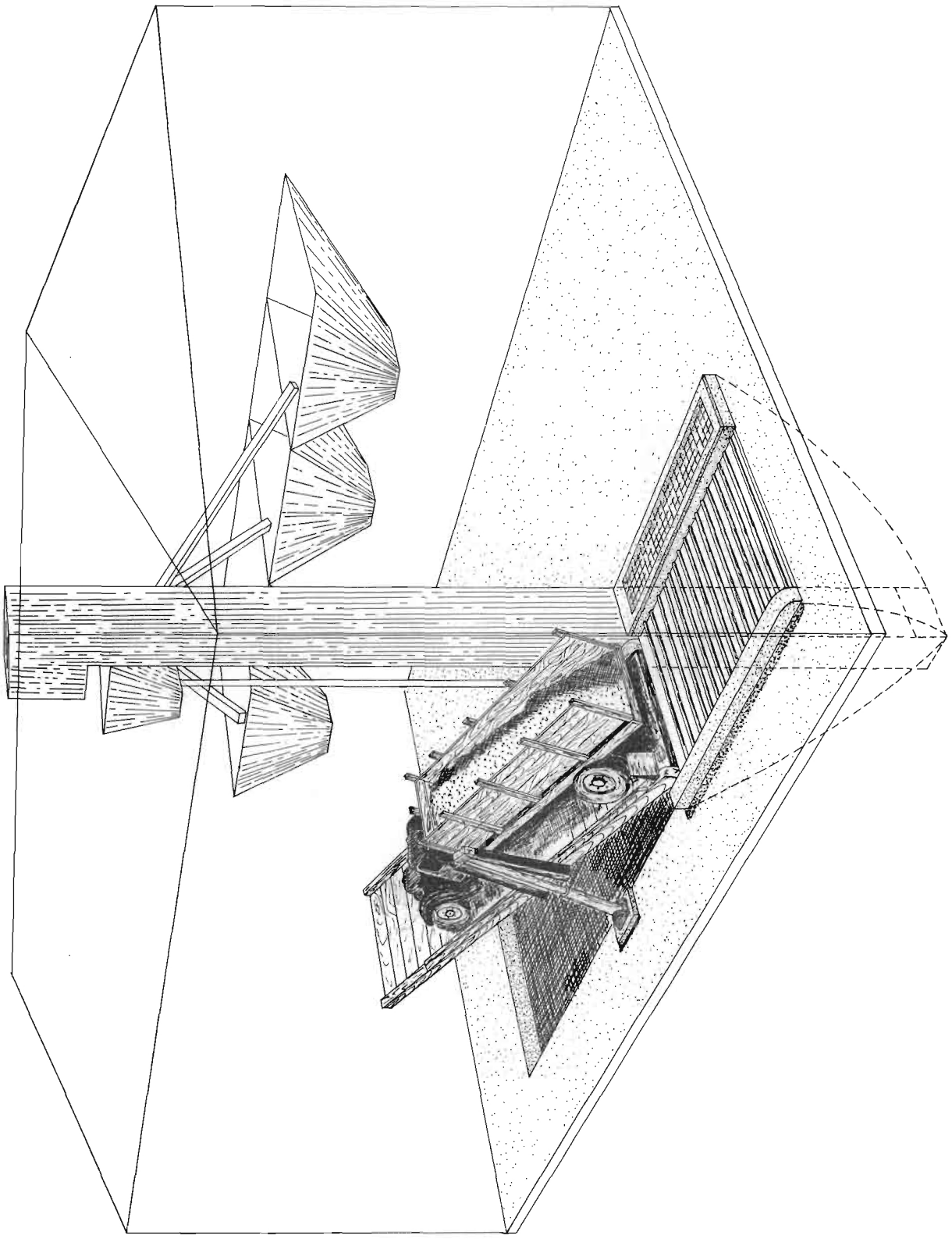

Figure 3. Equipment for Unloading, Reloading and Automatic Sampling.

With several holding bins provided, all but a small portion of the total five minutes can be used for unloading the dump pit. Thus, with an elevator capacity of 60 tons per hour, this unit will handle loads up to 10,000 pounds with no additional time required for pit unloading. Since over three-fourths of the peanut loads will be 10,000 pounds or less, the device should handle 12 trucks per hour; the occasional longer truck time will be balanced by the somewhat shorter time required for the very small trucks. On the basis of a 10-hour work day, this unit will then be capable of handling 120 trucks per day, and, assuming the average truck load to be 2-1/2 tons, this will give a daily capacity of 300 tons.

With the equipment shown in Figure 3, the sequence of operations would be as follows:

(1) Drive truck into place.
(2) Unload truck and drive out.
(3) Elevate peanuts to one of the several holding bins and automatically collect a representative sample.
(4) Bring truck into position at the appropriate holding bin.
(5) Reload the truck.

If pre-cleaning facilities are included with the equipment shown in Figure 3, the following procedure would be followed. This procedure will utilize the unloading and elevating facilities of the automatic sampler on those peanut loads which require pre-cleaning.

(1) Drive truck into place.
(2) Unload truck and drive out.
(3) Elevate peanuts to one of several holding bins and automatically collect a representative sample.
(4) Obtain a foreign material analysis on the above sample.
(5) If the foreign material content is below the maximum allowable level, reload the truck. If it is above the maximum allowable level, drop the peanuts into the pre-cleaner located below the holding bins.
(6) Clean, elevate, sample, and reload the peanuts onto the proper truck.

Cost estimates of the various types of equipment proposed were prepared. The cost of the unit shown in Figure 3 is approximately $11,000 with the cost breakdown as follows:

Building and Accessories (25-year timber)	$ 6,000
Hydraulic Hoist and Ramp	3,500
Bucket Elevator	1,500
Total	$11,000

These figures are based on all new equipment and complete contracting of the construction work. For small buying points, a unit having about half the capacity of the one illustrated could be built for about $6,000. A pre-cleaner, having an overall capacity of about 10 tons per hour, could be added for about $4,000. This pre-cleaner would consist of an air-blast, slot screen, stoner, elevator, and sampler.[5] A summary of these various proposals is given in Table II.

TABLE II

COSTS OF PROPOSED EQUIPMENT FOR AUTOMATIC SAMPLING AND PRE-CLEANING OF FARMERS' STOCK PEANUTS

Description of Unit	Sampling Capacity (Tons/Day)	Sampling Capacity (Trucks/Day)	Cleaning Capacity (Tons/Day)	Cost (Dollars)
Automatic Unloader and Sampler	150	60	--	6,000
Automatic Unloader and Sampler	300	120	--	11,000
Automatic Unloader, Sampler, and 1 Pre-Cleaner	150	60	100	11,000
Automatic Unloader, Sampler, and 1 Pre-Cleaner	300	120	100	15,000
Automatic Unloader, Sampler, and 3 Pre-Cleaners	300	120	300	23,000

[5]For a description of the construction and operation of the air-blast and slot-screen pre-cleaner see "Machinery for Cleaning Farmers' Stock Peanuts," Georgia State Engineering Experiment Station, July 1, 1951.

For most buying points, this type of sampling installation could be operated and paid for in one year at a cost of less than $2.00 per ton of peanuts bought. If the equipment costs were amortized over a period of 10 years, the sampling costs might be as low as $0.25 per ton of peanuts. Indications are that even $2.00 per ton would be a reasonable price to pay for assurance of obtaining representative samples of farmers' stock peanuts for grading, to forestall possible losses far greater than this amount.

A further possibility of considerable merit would be the pre-cleaning of all peanuts prior to storage. Reference to the equipment costs given in Table II indicates that this pre-cleaning cost would be approximately the same as the sampling costs indicated above. Thus, considering a 10 year ammortization period, the cost of sampling and pre-cleaning would be only about $0.50 per ton of peanuts. This seems to be a reasonable price to pay for the storage of clean peanuts, especially when out-grades must be guaranteed to equal in-grades.[6]

IV. EFFECTS OF REGRADES ON PEANUT PRICING

In addition to the error resulting from biased sampling, another factor, perhaps equally as important, is independently contributing to the mispricing of farmers' stock peanuts. This factor is "shopping around" by the seller. Even though both the seller and the buyer may call for a re-grade, the seller is placed at a decided advantage due to his knowledge and the buyer's ignorance of the true quality of the load of peanuts in question.

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[6]There are additional requirements which are also necessary to put the grading procedure on a sound guaranteed basis. These are pointed out in the next section of this report.

To make this point clear, first consider the damage analysis of a truck load of Runner peanuts which contains a true average of 8 per cent damage. If several 4-ounce samples (approximately 200 kernels each) are obtained from the truck in an unbiased manner, they will not all contain exactly 8 per cent damaged but will be distributed about an average of 8 per cent as shown below in Figure 4.

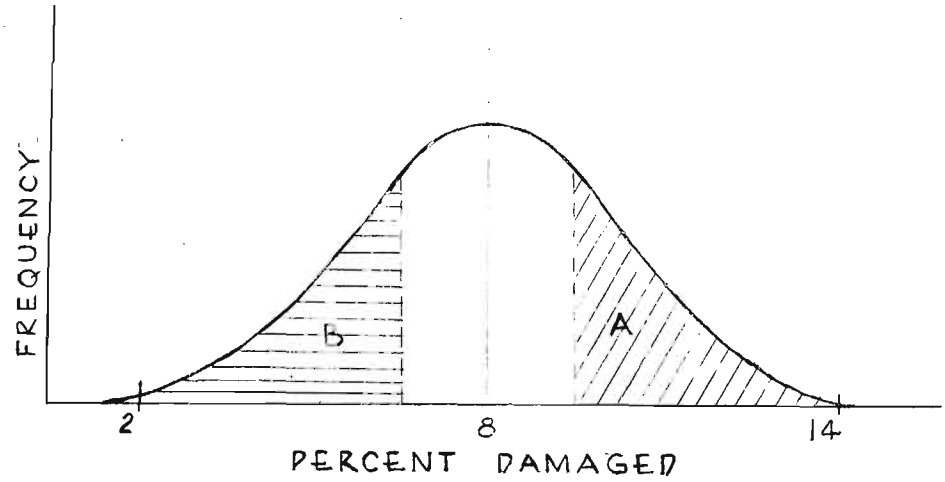

Figure 4. Frequency Distribution of Damaged Content of Repeated Samples of 200 Kernels Each.

It can be shown, by the application of mathematical probabilities and later by experimental results, that these samples may contain as low as 2 per cent and as high as 14 per cent damaged. The frequency of occurrence diminishes as the per cent damaged deviates farther from the average of 8 per cent.[7] This variation in repeated samples is merely due to chance and is always present, just as a pair of dice varies from 2 to 12 about its average of seven.

[7]The assumptions underlying these probability calculations together with a table showing the sampling variation for average per cent damage from 1 to 10 per cent, and for sample sizes of 4, 16, and 64 ounces, is given in Appendix A.

This frequency distribution as it stands does not, at first glance, reveal the trouble since it has the correct average of 8 per cent. To clarify this point, consider the effect of regrades demanded by the seller. It is not unreasonable to assume that the seller has a fairly good idea of the damage content of his peanuts. Thus, when chance variation results in a per cent damaged indicated by the shaded portion "A" of Figure 4, a regrade is usually demanded and rightly so, since the seller is literally being unjustly penalized by the excessive variability inherent in the present grading procedure. This per cent damaged when averaged with the first per cent damaged will, in most cases, be lower than the first per cent damaged alone. Thus, very few loads of peanuts will be sold at the percentages of damaged indicated in the shaded area A. The other possibility does not follow the same course of events. When the first per cent damaged is low, shown by the shaded area "B" in Figure 4, the seller is satisfied. The buyer usually has no reason to suspect this large unfavorable deviation, and, thus, seldom calls for a regrade. The result is that the frequency distribution of sample values shown in Figure 4 is not the same as the frequency distribution of samples on which sales are made. The latter is a skewed curve with the high values chopped off, due to averaging in regrades or "shopping around" by the seller. This new frequency distribution is shown in Figure 5 below.

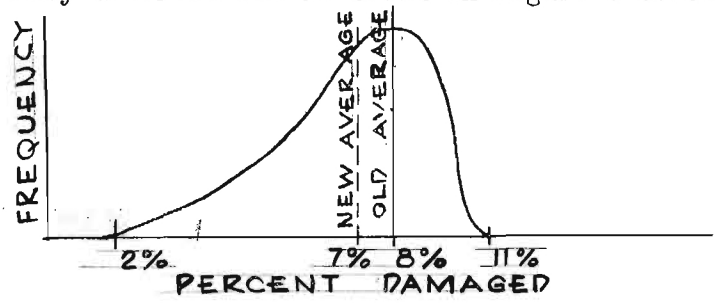

Figure 5. Effect of Regrades on Distribution Shown in Figure 4.

The average for this frequency distribution may very well be about 7 per cent, giving rise to a serious bias against the buyer.

The discussion above has been directed towards damage analysis. However, this same logic applies to the per cent of sound mature kernels and the per cent of foreign material in the load of peanuts.[8] The variations in per cent damaged, per cent of sound mature kernels and per cent of foreign material for repeated grades are additive. The combination of these factors gives rise to the variation in repeated estimates of the dollar value of a specific load of farmers' stock peanuts. Really, it is this dollar variation that the seller is especially interested in, and his knowledge of approximately what it should be places him at a decided marketing advantage.

To verify these claims of grade and dollar variations, a controlled experiment was conducted. Four truckloads of Spanish peanuts were selected for study. Twelve bucket samples were obtained (three from each truck), and each sample was then divided into eight portions for grading. Eight inspectors were then selected to grade one portion of each of the three samples from each of the four trucks. The damage analysis data are given in Table III below, the sound mature kernel analysis in Table IV, the foreign material analysis in Table V and the dollar value in Table VI.

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[8] The variability in the per cent moisture is probably unimportant if the moisture tester is properly adjusted and applied.

TABLE III

PER CENT DAMAGED FROM EXPERIMENTAL TESTS

	Truck 1			Truck 2			Truck 3			Truck 4		
	1	2	3	1	2	3	1	2	3	1	2	3
Inspector 1	6	5	4	4	5	4	6	4	3	2	2	2
Inspector 2	3	2	4	5	5	4	4	5	4	3	3	3
Inspector 3	3	3	4	5	6	4	4	3	5	3	3	2
Inspector 4	3	3	4	5	3	3	4	5	7	5	4	3
Inspector 5	4	3	4	8	6	3	6	6	4	3	1	3
Inspector 6	2	4	4	4	3	2	5	7	4	2	2	3
Inspector 7	5	3	3	4	3	5	3	3	6	5	3	2
Inspector 8	4	3	3	3	4	3	3	4	4	2	2	2
Truck Average	3.6			4.2			4.5			2.7		
Spread of Values	2-6			2-8			3-7			1-5		
Experimental Standard Deviation	0.93			1.32			1.25			0.95		
Theoretical Standard Deviation	1.13			1.22			1.27			0.99		

TABLE IV

PER CENT OF SOUND MATURE KERNELS FROM EXPERIMENTAL TESTS

	Truck 1			Truck 2			Truck 3			Truck 4		
	1	2	3	1	2	3	1	2	3	1	2	3
Inspector 1	67	70	70	65	66	64	68	68	72	74	74	75
Inspector 2	71	72	68	64	66	66	69	69	71	72	72	72
Inspector 3	71	68	69	62	63	65	69	70	68	71	71	75
Inspector 4	69	70	69	63	65	67	70	68	66	70	73	72
Inspector 5	69	71	71	60	63	65	70	66	70	72	71	73
Inspector 6	70	69	70	66	67	66	68	67	71	75	75	72
Inspector 7	68	71	71	65	66	65	69	69	68	71	72	73
Inspector 8	70	71	71	64	65	66	69	67	71	74	71	74
Truck Average	69.8			64.8			68.9			72.7		
Spread of Values	67-72			60-67			66-72			70-75		
Experimental Standard Deviation	1.27			1.65			1.57			1.52		

TABLE V

PER CENT OF FOREIGN MATERIAL FROM EXPERIMENTAL TESTS

	Truck 1			Truck 2			Truck 3			Truck 4		
	1	2	3	1	2	3	1	2	3	1	2	3
Inspector 1	5	5	5	5	9	7	4	3	3	2	2	1
Inspector 2	5	4	6	5	6	9	6	3	4	2	1	3
Inspector 3	4	6	4	6	8	6	2	5	4	1	2	2
Inspector 4	4	7	6	5	9	3	2	5	4	2	1	1
Inspector 5	6	8	5	5	8	13	3	3	5	1	2	1
Inspector 6	5	5	5	6	7	11	3	4	6	2	1	1
Inspector 7	3	5	4	7	6	9	4	4	7	2	1	2
Inspector 8	4	6	5	4	6	7	3	4	4	1	1	1
Truck Average	5.1			7.0			4.0			1.5		
Spread of Values	3-8			3-13			2-7			1-3		
Experimental Standard Deviation	1.10			2.25			1.23			0.59		

TABLE VI

VALUE OF PEANUTS IN DOLLARS PER TON FROM EXPERIMENTAL TESTS

	Truck 1			Truck 2			Truck 3			Truck 4		
	1	2	3	1	2	3	1	2	3	1	2	3
Inspector 1	191	204	207	192	180	183	198	206	222	234	234	240
Inspector 2	213	223	198	188	189	183	201	206	214	224	227	222
Inspector 3	217	201	207	176	171	189	211	210	201	223	221	240
Inspector 4	210	204	201	182	183	206	215	198	188	211	227	227
Inspector 5	201	204	210	162	171	171	206	193	207	227	228	230
Inspector 6	213	204	207	192	195	183	203	191	207	238	240	227
Inspector 7	203	213	217	186	195	177	210	210	189	215	227	231
Inspector 8	210	210	213	195	189	192	213	201	214	237	227	237
Truck Average	208			184			205			229		
Spread of Values	191-223			162-206			188-222			211-240		
Experimental Standard Deviation	7.0			9.8			8.8			7.4		

Table III shows the variation in damage analysis for the 24 (3 samples x 8 inspectors) determinations from each truck. For example, the 24 determinations from truck two showed an average damage of 4.2 per cent, while the individual determinations ranged from 2 to 8 per cent. A complete statistical analysis of these data indicated that the results obtained by each inspector were not significantly different from those obtained by the other inspectors.[9] More specifically, there was no significant difference between the experimental technique and the judgment of the eight inspectors. Similarly, analyses of the three bucket samples as a whole showed no significant difference for each truck. This is what is expected, since damaged peanuts are distributed at random throughout the load of peanuts. Thus, the variation of repeated damage analyses for each truck can be attributed entirely to chance variation in the damage content of the four-ounce sample analyzed. This conclusion is further verified by the close agreement of the standard deviation,[10] calculated from the experimental data, and the theoretical standard deviation, which is based upon the mathematical laws of chance. Since chance is the only significant factor effecting the variability in damage analysis, only one thing can and need be done to decrease this variability. That is increasing the size of the sample used for analysis. In general, if the sample size is quadrupled, the variability in the samples will be cut in half. For example, if the present four-ounce sample is increased to 16 ounces, the present variability in

[9] The technique used is known as the analysis of variance.

[10] Standard deviation is a mathematical measure of the variability of numerical data.

damage analyses is reduced by one-half. The effect of sample size on the variability in damage analyses for Runner peanuts is brought out in Table X in the Appendix of the report. Further comments about the sample size will be made later.

Data in Table IV showing the per cent of sound mature kernels for these experimental tests were analyzed in the same manner as indicated above for the damage analyses. Conclusions reached are identical with those on damage, as expected, since the sound mature kernel count depends on the damage analysis. The variability of these data is slightly greater than that of the damage analysis data, however, since the sound mature kernel count is affected by other kernels as well as by the damage content.

The results of the analysis of Table V, giving the per cent of foreign material for these experimental tests, differed somewhat from the others. The variations among inspectors was again insignificant. However, the variations among the three bucket samples as a whole from each truck were significant. This is attributed to the fact that foreign material is not randomly distributed throughout the load of peanuts and to the manner in which the sample is obtained. Another point brought out by these data shows that the variability in the foreign material determinations increases as the amount of foreign material present increases. For example, the individual analyses from truck four, which had an average foreign material content of 1.5 per cent, varied from 1 to 3 per cent. Individual analyses from truck two, having an average foreign material content of 7.0 per cent, varied from 3 to 13 per cent.

These facts lead to the following recommendations for decreasing the variability in foreign material determinations.

(1) Unload each truck, and obtain an unbiased sample as it is being reloaded to eliminate the significant variability between samples.[11]

(2) Increase the size of the sample analyzed to reduce the random chance variation between samples.

(3) Require pre-cleaning of all loads having foreign material in excess of about 5 per cent to further reduce the magnitude of the random chance variation between samples.

Table VI gives a composite picture of the effect of the variabilities (indicated in Tables III, IV, and V) on the dollar value of the peanut loads in question. For example, the average of the 24 grades on truck two fixed the value of these peanuts at $184 per ton with the individual values ranging from $160 to $206 per ton. If more analyses were made, this variation would be even greater as indicated in Figure 6.

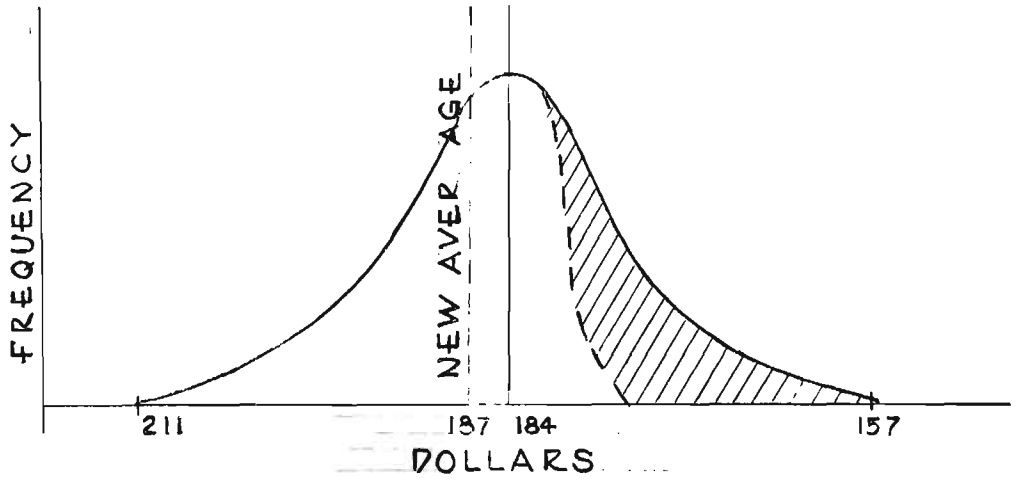

Figure 6. Variation in the Value of Peanuts in Dollars per Ton for the Present Grading System.

[11] This will also eliminate errors due to scientific loading.

If we assume that one-fourth of the peanuts sold are sold on the basis of regrades, the upper one-fourth of the frequency distribution (shaded area) will be cut off. If we further assume that these loads are finally sold at the average price of $184, the average price paid for all loads will have been raised to $187. This extra price of $3 per ton, although a considerable one, is probably a conservative figure. It should be re-emphasized here that the seller who demands a regrade should not be criticized, since he is doing so merely to get a just price for his peanuts. It is the seller who chances to get a favorable price for his peanuts at the first sampling, who is really profiting.

This conclusion is verified by a tabulation of 200 regrades of Runner peanuts and 38 regrades of Spanish peanuts which were selected at random from the 1951 buying season records. These data which are presented in Tables VIII and IX give the per cent damaged, the per cent of sound mature kernels, and the per cent of foreign material on the first grade and the second, or regrade. The last column listed, "Value of the Second Grade Minus the Value of the First Grade," was computed by assigning a $3.20 value to each percentage point. For example, the first load listed in Table VIII had a decrease of 1 per cent damaged, thus increasing the second value by $3.20; a decrease of 1 per cent of sound mature kernels, thus decreasing the second value by $3.20; and a 2 per cent increase of foreign material, thus decreasing the second value by $6.40. The "Value of the Second Grade Minus the Value of the First Grade" is therefore the net result of these three factors, or ($3.20) - ($3.20) - ($6.40) = - $6.40. The algebraic average[12] of these 200 values for Runner peanuts is + $6.43

[12] This average was obtained by subtracting the sum of the negative values from the sum of the positive values and dividing the resultant value by 200.

per ton, and for the 38 values for Spanish peanuts, it is + $2.95 per ton. These high "plus" differences verify the above conclusion that, in general, the seller demands a regrade when the first grade underestimates the value of his peanuts, and, as the above averages show, the regrades usually increase the value of the peanuts. The net result of this is to raise the average price paid for all the peanuts above its true value.

The arithmetical average[13] of the "Value of the Second Grade Minus the Value of the First Grade" is ± $13.92 for the Runner peanuts and ± $12.25 for the Spanish peanuts. With such large average differences, there is little doubt that a reduction of variability in grading procedures is needed. To show that this can be accomplished by increasing the sample size, the date of Tables VIII and IX, together with Table VII, were analyzed. Table VII shows the results of 38 check tests on Runner peanuts. Each load of peanuts was graded 4 times using twice the conventional sample size, i.e., 16 ounces for foreign material and 8 ounces for damage and sound mature kernel analysis. These data were analyzed by grouping together loads having about the same damage content. The average damage content and the average range between duplicate analyses were then calculated for each group. In the case of Table VII, the range between the highest and lowest damage content of the four repeat determinations was converted to an equivalent range for duplicate analyses by the use of mathematical statistics. This was done to put the results of Table VII on the same basis as those of Tables VIII and IX. The results of these analyses are shown in Figure 7 for Runner peanuts and in Figure 8 for Spanish peanuts. These figures compare the average ranges between

[13] This average was obtained by dividing the sum of all the values, without regard to sign, by 200.

TABLE VII

CHECK TESTS ON 8-OUNCE SAMPLES OF RUNNER PEANUTS

No.	Certificate Number	Per Cent Foreign Material						Per Cent Damage						Per Cent Sound Mature Kernels						Total Weights			
		Sample No.				Avg.	Range	Sample No.				Avg.	Range	Sample No.				Avg.	Range	Sample Number			
		1	2	3	4			1	2	3	4			1	2	3	4			1	2	3	4
1	556769	4	3	4	3	3.50	1	8	9	8	4	7.25	5	65	64	63	65	64.25	2	100	101	100	99
2	556719	2	2	1	2	1.75	1	10	7	9	6	8.00	4	62	65	61	66	63.5	5	100	100	99	100
3	556725	5	6	5	5	5.25	1	9	8	8	7	8.00	2	63	62	63	63	62.75	1	100	99	101	100
4	556721	5	5	6	7	5.75	2	6	7	4	7	6.00	3	63	60	66	65	63.50	6	99	100	99	100
5	556720	5	5	6	4	5.00	2	6	5	6	8	6.25	3	65	67	66	64	65.50	3	100	99	99	101
6	556718	1	2	2	2	1.75	1	9	7	8	8	8.00	2	63	64	63	64	63.50	1	100	100	99	99
7	--	5	3	5	5	4.50	2	4	3	3	3	3.25	1	67	66	67	67	66.75	1	100	99	99	99
8	553280	5	5	4	4	4.50	1	8	12	13	8	10.25	5	62	55	57	61	58.75	7	100	100	101	99
9	--	5	5	5	5	5.00	0	9	8	9	7	8.25	2	61	63	62	62	62.00	2	100	101	100	100
10	528694	3	2	3	3	2.75	1	6	5	5	5	5.25	1	65	65	65	63	64.50	2	100	99	100	99
11	--	6	6	6	9	6.75	3	11	12	12	15	12.50	4	56	54	56	53	54.75	3	99	99	100	100
12	540708	3	2	3	2	2.50	1	4	5	4	6	4.75	2	62	65	63	61	62.75	4	99	100	99	99
13	577201	2	4	4	3	3.25	2	6	5	6	5	5.50	1	65	65	64	63	64.25	2	100	100	99	100
14	577203	8	5	6	6	6.25	3	4	5	4	5	4.50	1	64	64	65	62	63.75	3	99	100	101	99
15	556145	3	3	4	2	3.00	2	6	6	7	6	6.25	1	65	65	64	63	64.25	2	99	99	100	100
16	576446	4	2	3	3	3.00	2	7	4	6	8	5.25	4	64	65	62	62	63.25	3	100	99	99	99
17	--	8	6	5	9	7.00	4	3	4	4	6	4.25	3	66	66	65	62	64.75	4	99	100	99	99
18	577205	10	15	10	11	11.50	5	4	6	4	4	4.50	2	65	62	63	65	63.75	3	100	99	99	99
19	556177	4	5	6	5	5.00	2	8	10	10	9	9.25	2	61	58	58	59	59.0	3	99	100	99	99
20	556175	2	5	4	2	3.25	3	12	9	10	11	10.50	3	57	50	59	59	58.75	3	100	100	100	100
21	553191	6	4	6	5	5.25	2	5	4	5	5	4.75	1	65	65	65	66	65.25	1	100	99	101	100
22	--	8	6	8	7	7.25	2	9	10	7	8	8.50	3	60	58	62	62	60.50	4	100	100	100	99
23	577210	11	10	12	11	11.00	2	6	4	5	4	4.75	2	63	65	63	66	64.25	3	100	99	99	99
24	556332	7	4	6	5	5.50	3	5	5	4	6	5.00	2	67	67	66	65	66.25	2	100	100	99	100
25	556162	3	2	3	2	2.50	1	5	4	4	5	4.50	1	63	63	64	64	63.50	1	99	100	99	100
26	--	3	2	2	2	2.25	1	9	7	8	9	8.25	2	61	62	64	60	61.75	4	99	99	100	99
27	--	4	4	5	5	4.50	1	6	6	7	6	6.25	1	65	64	64	64	64.25	1	100	99	99	99
28	--	4	3	6	4	4.25	3	5	5	5	5	5.00	0	65	64	68	67	66.00	4	100	99	101	100
29	--	3	3	2	3	2.75	1	2	5	3	5	3.75	3	69	65	70	69	68.25	5	99	99	99	101
30	--	4	4	5	5	4.50	1	3	3	5	5	4.00	2	64	64	64	65	64.25	1	99	99	100	100
31	--	3	3	4	3	3.25	1	4	3	3	4	3.50	1	69	70	69	68	69.00	2	100	100	100	100

(Continued)

TABLE VII (Continued)

CHECK TESTS ON 8-OUNCE SAMPLES OF RUNNER PEANUTS

No.	Certificate Number	Per Cent Foreign Material						Per Cent Damage						Per Cent Sound Mature Kernels						Total Weights			
		Sample No.				Avg.	Range	Sample No.				Avg.	Range	Sample No.				Avg.	Range	Sample Number			
		1	2	3	4			1	2	3	4			1	2	3	4			1	2	3	4
32	--	5	4	5	4	4.50	1	7	6	3	6	5.50	4	64	65	68	64	65.25	4	100	100	100	100
33	--	4	3	2	3	3.00	2	5	5	4	4	4.50	1	65	66	67	67	66.25	2	100	99	99	99
34	--	4	4	2	3	3.25	2	9	10	10	11	9.75	3	64	62	59	58	60.75	6	99	101	99	100
35	--	7	5	5	5	5.50	2	3	3	5	5	4.00	2	68	70	65	66	67.25	5	100	99	100	100
36	--	3	3	3	4	3.25	1	2	5	3	4	3.50	3	69	68	67	67	67.75	2	100	100	100	99
37	--	3	3	3	3	3.00	0	4	6	5	7	5.50	3	66	67	64	62	64.75	5	100	100	99	99
38	--	8	8	8	7	7.75	1	2	5	4	4	3.75	3	73	69	67	69	69.50	6	100	99	99	100

TABLE VIII

GOVERNMENT INSPECTOR REGRADES OF RUNNER PEANUTS

Certificate Number	Per Cent Damaged		Per Cent of Sound Mature Kernels		Per Cent of Foreign Material		Value of Second Grade Minus the Value of First Grade (Dollars)
	First	Second	First	Second	First	Second	
182115	8	7	60	59	7	9	-6.40
182055	6	6	63	64	4	5	0.00
52995	5	2	61	65	7	6	25.60
52820	6	3	60	63	7	5	25.60
52680	5	4	60	65	5	5	19.20
52719	3	2	63	64	3	5	0.00
52588	8	5	63	65	4	5	12.80
52598	10	12	55	57	14	8-7	22.40
51426	8	6	61	60	8	-	3.20
52516	3	3	61	63	6	4	12.80
52536	2	4	59	63	10	5	22.40
192160	10	8	63	65	3	3	12.80
192168	12	9	60	62	3	3	16.0
192178	7	5	62	63	2	6	-3.20
192189	6	1	61	66	3	4	28.80
192225	8	7	56	60	12	9	25.60
192230	11	12	59	60	10	11	-3.20
192336	8	12	62	56	10	8	0.00
192344	7	5	64	65	9	7	16.00
192360	6	2	63	67	6	6	25.60
192477	9	9	62	62	4	6	-6.40
192467	8	7	59	62	3	3	12.80
192430	9	4	59	65	3	-	35.20
192432	4	4	51	52	8	11	-6.40
192436	1	1	63	69	7	7	19.20
192314	8	8	58	58	4	6	-6.40
192237	9	8	58	61	6	7	9.60
192271	5	4	65	64	3	5	-6.40
192321	3	2	69	70	10	6	19.20

(Continued)

TABLE VIII (Continued)

GOVERNMENT INSPECTOR REGRADES OF RUNNER PEANUTS

Certificate Number	Per Cent Damaged		Per Cent of Sound Mature Kernels		Per Cent of Foreign Material		Value of Second Grade Minus the Value of First Grade
	First	Second	First	Second	First	Second	(Dollars)
192324	8	7	59	53	7	6	-12.80
192387	8	5	63	67	3	3	22.40
192403	3	6	69	64	7	5	-19.20
182309	6	3	65	67	2	3	12.80
182322	8	7	62	62	9	7	9.60
192133	9	13	63	56	6	5	-32.00
192124	5	4	67	69	10	9	12.80
192104	14	10	56	61	8	10	22.40
192098	9	12	66	62	3	2	-19.20
192062	14	9	55	58	16-9	12	41.60
192042	4	5	64	62	10	10	-9.60
192025	5	6	65	65	7	5	3.20
52938	4	4	62	60	4	7	-16.00
52878	3	2	62	64	14	-	9.60
52868	3	4	62	60	6	7	-12.80
52865	2	0	67	72	5	6	19.20
194585	8	7	65	63	3	2	0.00
194546	2	1	61	65	2	3	12.80
194531	1	0	69	66	10	10	-6.40
194579	1	1	54	58	10	5	28.80
194618	5	5	66	64	6	7	-9.60
182430	12	11	60	60	3	3	3.20
182419	9	6	64	67	15	10	35.20
182405	6	5	58	62	12	12	16.00
182410	10	12	58	59	5	7	-9.60
194985	8	6	63	65	9	5	25.60
194728	7	4	57	62	2	4	19.20
182486	8	6	66	66	13	11	12.80
194735	6	7	56	55	10	12	-12.80
194740	3	0	64	70	6	5	32.00

(Continued)

TABLE VIII (Continued)

GOVERNMENT INSPECTOR REGRADES OF RUNNER PEANUTS

Certificate Number	Per Cent Damaged		Per Cent of Sound Mature Kernels		Per Cent of Foreign Material		Value of Second Grade Minus the Value of First Grade
	First	Second	First	Second	First	Second	(Dollars)
194643	7	6	63	64	3	3	6.40
194692	8	6	64	65	5	3	16.00
194700	5	9	63	61	5	4	-16.00
194849	6	5	62	59	7	7	-6.40
194851	8	6	62	64	1	2	9.60
194854	9	4	56	60	4	9	12.80
194862	9	7	64	63	1	2	0.00
194876	8	11	63	58	8	8	-25.60
194908	8	8	63	65	7	3	19.20
194900	8	9	61	61	8	5	6.40
52049	9	13	61	55	10	11	-35.20
52070	4	2	64	66	3	4	9.60
52072	7	5	55	59	8	7	22.40
52112	6	4	61	67	3	-	25.60
52132	7	5	65	64	5	6	0.00
52169	4	3	56	60	3	2	19.20
52170	5	5	60	64	6	8	6.40
52171	8	10	61	61	3	6	-16.00
52184	6	4	61	63	3	3	0.00
52185	10	12	56	55	7	3	3.20
52195	10	6	63	68	3	3	28.80
52197	10	5	60	62	9	11	16.00
52202	8	7	60	62	3	2	12.80
52208	7	7	60	59	7	5	3.20
221	8	7	56	54	7	6	0.00
230	7	10	60	59	6	4	-6.40
243	10	14	60	56	4	3	-22.40
247	9	10	55	58	10	8	12.80
50661	8	7	62	62	2	2	3.20
677	5	9	62	64	4	2	0.00
686	6	6	63	63	5	2	9.60

(Continued)

TABLE VIII (Continued)

GOVERNMENT INSPECTOR REGRADES OF RUNNER PEANUTS

Certificate Number	Per Cent Damaged		Per Cent of Sound Mature Kernels		Per Cent of Foreign Material		Value of Second Grade Minus the Value of First Grade
	First	Second	First	Second	First	Second	(Dollars)
688	12	8	61	63	4	4	19.20
697	8	6	63	63	2	2	6.40
52263	9	10	62	62	3	2	0.00
265	8	4	64	70	4	3	35.20
282	8	7	52	53	11	12	3.20
294	15	13	52	53	4	4	9.60
300	3	2	63	66	8	6	19.20
304	8	10	61	58	13	13	-16.00
306	8	6	61	65	10	8	25.60
322	9	8	59	60	2	2	6.40
327	16	6	55	64	6	5	6.40
328	4	2	49	51	10	8	19.20
329	5	3	69	69	7	8	3.20
334	3	6	65	64	3	4	-16.00
345	11	10	59	60	7	4	16.00
347	6	4	56	59	5	5	16.00
351	8	6	62	63	4	5	6.40
357	9	11	62	63	5	3	3.20
360	4	6	58	58	9	7	0.00
384	6	3	61	65	2	3	19.20
386	10	8	57	61	10	11	16.00
387	5	9	63	60	11	9	-16.00
388	9	7	62	61	7	6	6.40
394	8	12	64	56	5	4	-35.20
397	10	6	51	52	8	9	12.80
410	10	11	56	58	4	6	-3.20
414	13	13	57	57	13	10	9.60
419	5	5	64	66	4	5	3.20
422	4	5	66	66	10	12	-9.60
423	4	7	60	58	9	11	-22.40
425	8	10	57	56	3	-	-9.60
428	3	3	55	59	7	-	12.80

(Continued)

TABLE VIII (Continued)

GOVERNMENT INSPECTOR REGRADES OF RUNNER PEANUTS

Certificate Number	Per Cent Damaged		Per Cent of Sound Mature Kernels		Per Cent of Foreign Material		Value of Second Grade Minus the Value of First Grade
	First	Second	First	Second	First	Second	(Dollars)
52429	5	4	59	60	5	6	3.20
432	6	3	64	66	6	-	16.00
436	10	5	55	60	5	14	3.20
178635	5	4	64	69	6	5	22.40
181062	9	13	61	55	5	5	-32.00
487	7	6	62	66	6	12	-3.20
316	7	6	63	65	8	3	25.60
135	8	10	61	60	13	7	9.60
107	8	8	62	62	2	2	0.00
347	8	11	61	60	5	3	-6.40
—	5	4	69	67	3	8	-19.20
484	16	15	53	54	4	4	6.40
62584	9	3	61	66	7	5	41.60
181114	7	4	61	62	4	3	16.00
164	9	11	60	54	8	6	-19.20
—	2	1	62	66	4	4	16.00
62766	10	8	63	65	4	5	9.60
181187	9	5	59	63	6	-	25.60
62561	2	2	64	63	5	8	-12.80
544	8	6	57	62	3	7	9.60
—	3	2	45	45	5	3	9.60
141894	4	4	61	62	10	12	-3.20
780	5	4	63	67	12	8	28.80
142139	3	2	65	64	13	11	6.40
140	8	8	63	63	10	4	19.20
120	4	3	61	64	4	4	12.80
111	6	6	65	62	16	10	9.60
141614	7	4	62	66	4	8	9.60
638	9	10	58	58	8	6	3.20
696	5	4	64	63	6	4	6.40
134926	8	10	49	52	6	8	-3.20
—	8	12	62	59	6	7	-25.60

(Continued)

TABLE VIII (Continued)

GOVERNMENT INSPECTOR REGRADES OF RUNNER PEANUTS

Certificate Number	Per Cent Damaged		Per Cent of Sound Mature Kernels		Per Cent of Foreign Material		Value of Second Grade Minus the Value of First Grade
	First	Second	First	Second	First	Second	(Dollars)
141740	9	8	64	65	3	5	0.00
727	8	8	61	60	7	15	-28.80
712	9	4	60	66	11	8	44.80
702	2	4	68	67	2	2	-9.60
70457-8	7	7	65	66	4	7	-6.40
70455-56	5	5	67	69	4	3	9.60
70456-55	0	1	75	74	5	7	-12.80
69008-70454	2	3	72	71	2	3	-9.60
69006-7	3	4	68	69	5	5	0.00
139609-12	1	2	73	73	4	6	-9.60
144611	8	9	64	62	2	1	-6.40
6771	2	1	56	59	10	-	12.80
6791	6	2	68	71	1	1	22.40
173562	6	6	68	69	7	10	-6.40
176536-7	8	7	60	62	9	4	25.60
6698	3	2	57	58	2	2	6.40
69239	8	5	51	56	5	4	28.80
129934	8	6	62	66	6	3	28.80
129942	9	9	58	57	5	5	-3.20
193731	4	3	60	61	5	4	9.60
139816	9	7	61	62	7	4	19.20
90157-8	9	4	62	69	4	4	38.40
90412-36	8	10	57	57	2	2	-6.40
90251-467	9	8	58	61	3	5	6.40
90417-45	9	7	56	62	6	7	22.40
90223-4	9	6	64	64	1	3	3.20
176684-985	10	11	64	60	4	4	-16.00
141321	8	7	62	62	3	1	9.60
90108-9	9	4	60	67	1	2	35.20
90149-93796	1	1	60	62	5	7	0.00
90231-2	8	3	60	64	9	3	48.00

(Concluded)

TABLE VIII (Concluded)

GOVERNMENT INSPECTOR REGRADES OF RUNNER PEANUTS

Certificate Number	Per Cent Damaged		Per Cent of Sound Mature Kernels		Per Cent of Foreign Material		Value of Second Grade Minus the Value of First Grade
	First	Second	First	Second	First	Second	(Dollars)
90220-1	10	12	58	57	2	3	-12.80
90125-6	9	5	61	63	8	9	16.00
90140-71	10	8	59	62	6	5	19.20
90128-31	7	6	62	62	3	3	3.20
173661-2	4	5	63	62	2	3	-9.60
138880-1	7	3	57	65	3	3	35.20
90017-8	9	8	56	58	4	5	6.40
90066-7	7	9	64	63	10	8	-3.20
138683-6	8	6	63	65	1	2	9.60
138593-4	6	8	57	57	2	2	-6.40
138635-7	10	15	57	555	3	3	-22.40
93655-6	7	7	62	62	3	2	3.20
71532	14	11	57	58	8	6	19.20
144805	8	6	60	62	1	2	16.00
144805	8	6	63	62	4	4	3.20

TABLE IX

GOVERNMENT INSPECTOR REGRADES OF SPANISH PEANUTS

Certificate Number	Per Cent Damaged		Per Cent of Sound Mature Kernels		Per Cent of Foreign Material		Value of Second Grade Minus the Value of First Grade
	First	Second	First	Second	First	Second	(Dollars)
51186	5	2	56	56	10	8	16.50
51118	3	1	64	67	6	5	19.80
51329	7	5	61	65	4	5	13.20
52040	7	2	65	69	8	6	36.30
52098	8	3	55	58	4	-	26.40
52158	1	1	66	67	3	5	-3.30
52172	6	5	66	69	6	6	13.20
52066	8	6	61	63	5	-	13.20
192126	7	4	65	67	6	4	23.10
192227	4	4	69	68	6	6	-3.30
192154	5	4	66	69	3	4	9.90
51436	5	4	65	62	9	7	0.00
178681	3	4	66	67	7	7	0.00
181188	9	10	60	59	2	-	-6.60
62877	3	3	65	65	3	3	0.00
62888	4	5	63	64	2	2	0.00
181173	10	14	60	54	5	6	-36.30
141757	6	7	67	64	2	3	-16.50
141726	4	3	65	69	6	8	9.90
141717	4	2	65	69	-	-	19.80
141674	4	6	61	62	3	5	-16.50
180928	6	6	65	64	6	8	-9.90
141620	4	2	69	71	3	3	13.20
141611	3	2	68	69	5	9	-6.60
553922	3	2	65	68	5	4	16.50
553925	2	2	68	70	7	8	3.30
142145	5	9	61	60	4	7	-26.40
141851	8	8	61	62	4	5	0.00
141821	6	9	64	61	9	11	-26.40
139616-26	0	1	72	70	2	3	-13.20

(Continued)

TABLE IX (Continued)

GOVERNMENTIINSPECTOR REGRADES OF SPANISH PEANUTS

Certificate Number	Per Cent Damaged		Per Cent of Sound Mature Kernels		Per Cent of Foreign Material		Value of Second Grade Minus the Value of First Grade (Dollars)
	First	Second	First	Second	First	Second	
139630	2	2	67	67	3	3	0.00
180068	7	6	66	68	6	-	9.90
90279-415	8	7	63	62	5	4	3.30
1006	5	6	66	65	8	7	-3.30
182444	9	6	61	66	2	3	23.10
181001	7	10	61	59	4	4	-16.50
183437	7	9	65	64	5	3	-6.60
51133	4	6	64	63	6	6	3.30

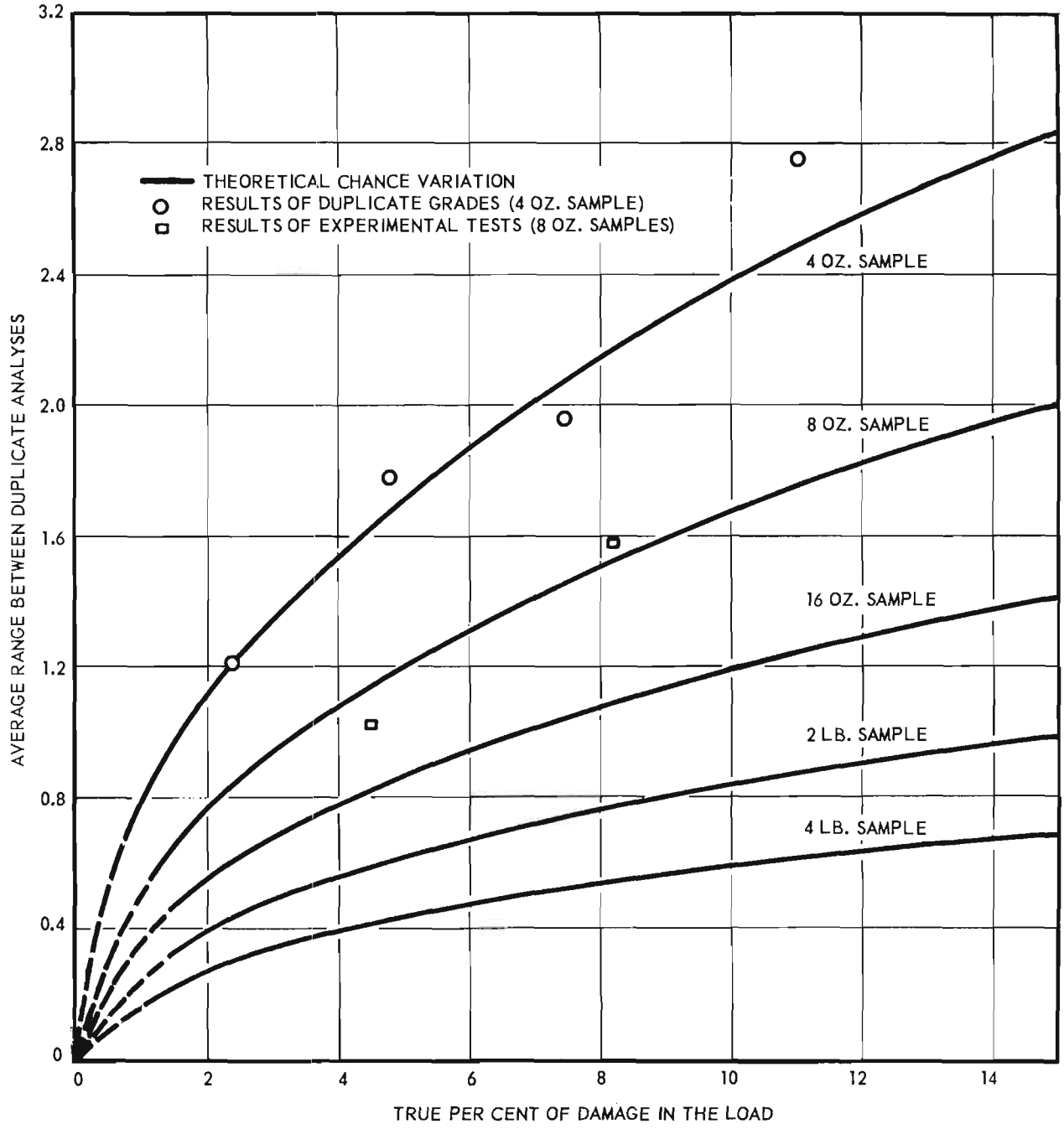

Figure 7. Average Range between Duplicate Analyses as a Function of Damage Content for Runner Peanuts.

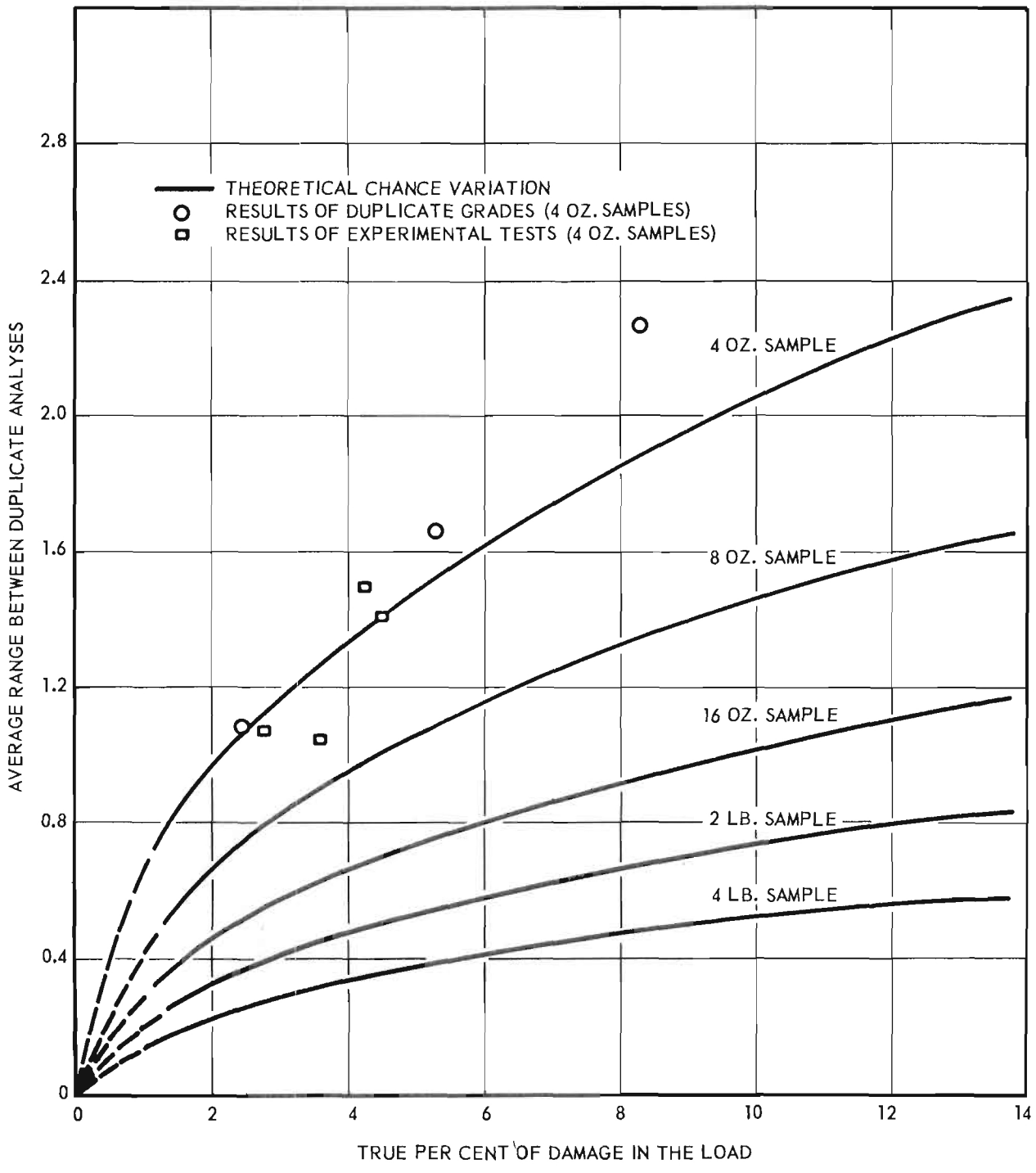

Figure 8. Average Range between Duplicate Analyses as a Function of Damage Content for Spanish Peanuts.

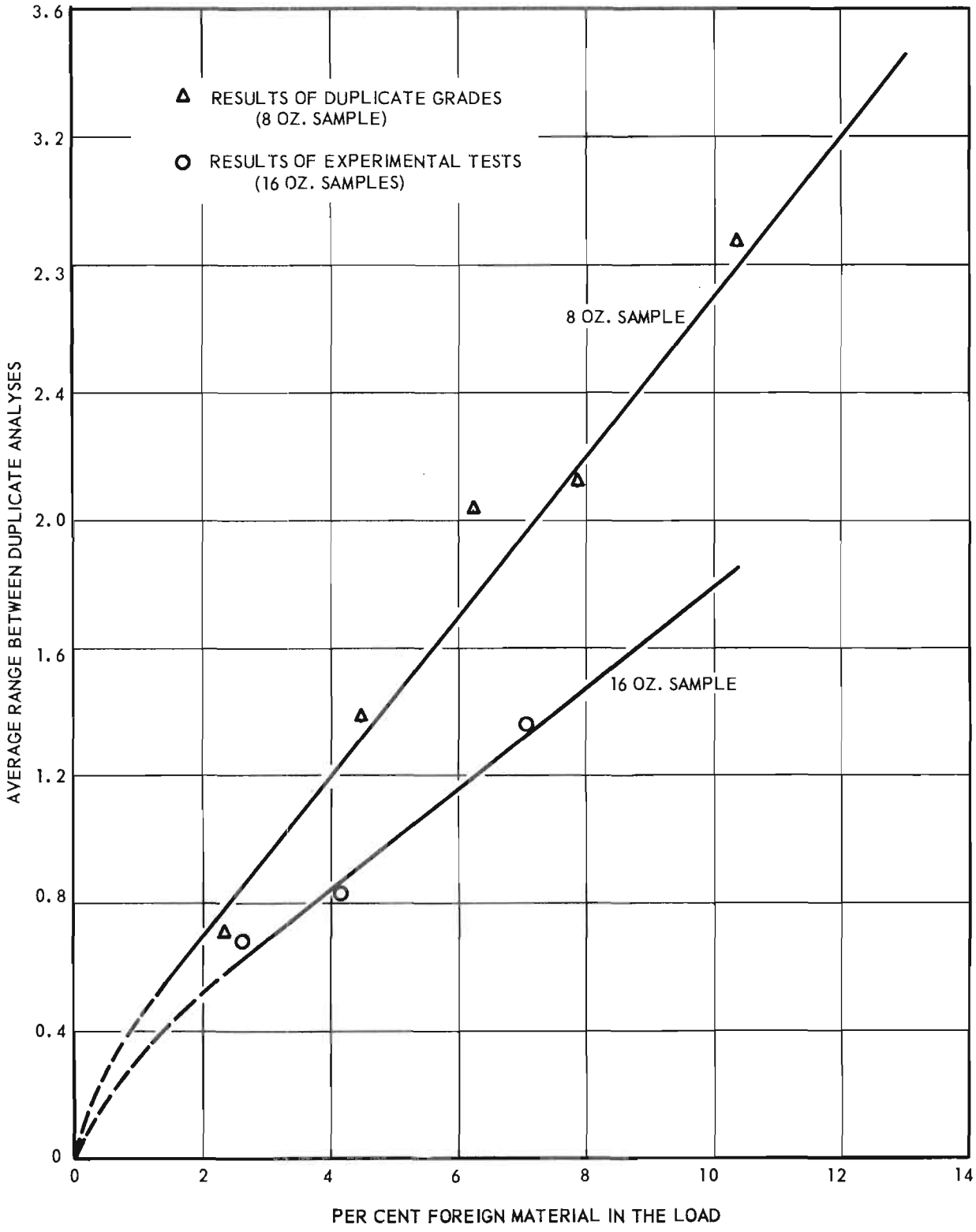

Figure 9. Experimental Average Range between Duplicate Analyses as a Function of Foreign Material Content for Spanish and Runner Peanuts.

duplicate analyses with the per cent damaged in the load. The solid lines marked with parameters of sample size are the theoretical values which are based on the fundamental laws of chance. The agreement between the experimental points and the theoretical lines is excellent. This supplies further evidence that the variation in repeat analyses is merely due to the chance variation in the sample selected. It also strengthens the claim that increased sample sizes will reduce the variation as predicted by the mathematical laws of chance. An analysis of the foreign material determinations is given in Figure 9 in which the average range between duplicate analyses is plotted as a function of the per cent of foreign material in the load. This figure clearly shows the reduction in variability obtained by increasing the sample size from 8 ounces to 16 ounces.

Since the variations of dollar value for farmers' stock peanuts (given in Tables VI, VIII and IX) result from the composite of the variations in the damage, sound mature kernel and foreign material analyses, a reduction in these individual variations will correspondingly reduce the dollar variations. It is not necessary--in fact, it is impossible--to eliminate all variation in this dollar value. It is only necessary to reduce it to the point where regrades will not be necessary or profitable from the seller's point of view. This latter statement may well be considered as one goal of the grading procedure. The question now arises: "What sample size will accomplish this goal?" To attempt to answer this question quantitatively would be foolhardy when one considers that such factors as the size and quality of the load of peanuts and the seller's valuation of his time, as well as his personal

feelings about the grading procedure, all affect the answer to this question. Nevertheless, a few qualitative statements can be made which will help in choosing the necessary sample size.

(1) The size of the load of peanuts affects the sample size required. Since larger loads mean more dollars are at stake, a larger sample should be graded for trailer trucks than for a small pickup truck.

(2) The type of peanuts affects the sample size required, since Spanish peanuts contain approximately 35 per cent more kernels per unit weight than do Runner peanuts. Therefore, for grades of equal reliability, the Runner peanut sample should be about one third larger than the Spanish peanut sample.

(3) The quality of the peanuts in question affects the variability in the grades. High-damage-content peanuts require a larger sample than low-damage-content peanuts to obtain grades of equal reliability.

(4) Any increase at all in the sample size will be helpful as shown in Figures 7 and 8 above. However, the variability in grades is inversely proportional to the square root of the sample size. Thus, the effect of increasing the sample size soon reaches the point of diminishing returns. This point seems to be about two pounds.

Following all of the above recommendations in specifying the sample size would result in an unwieldy grading procedure. However, points (1) and (4) seem to be worth consideration. If a 2-pound sample is specified, the variability in grades will be reduced to about one-third the present value. If we therefore accept the average differences in regrade values of Runner peanuts to be $\pm$ \$13.92 as given in Table VIII, this will be reduced to $\pm$ \$4.93. Since the grades are averaged,

this will amount to an average difference in the first grade and the first-plus-second grade of ± $2.46. For Spanish peanuts, this latter figure would be about ± $2.17. It seems that average differences of this magnitude should discourage and eventually eliminate regrading. It would be well, however, to reconsider point (1) which would perhaps call for a double-size sample for peanut loads over about 8 or 10 tons.

Grading a 2-pound sample will undoubtedly require some automatic equipment. A description of proposed equipment for this purpose will be given in a later report.

The conclusions and recommendations reached from these grading experiments may be summarized in four items.

(1) Variation among inspectors was not significant. This indicates that the standards of judgment and the experimental techniques of the inspectors are well established. Only one recommendation is in order here. In rounding off numbers like 1.5, 4.5, etc., one should always round off to an even number. Thus 1.5 would be rounded off to 2.0 and 4.5 would be rounded off to 4.0. If this procedure is not followed, and the practice is always to round off upward or downward, a small but consistent bias is introduced. This point is of particular importance in obtaining averages of regrades. Here the practice of always rounding off upward is unfair to the seller since only the sound mature kernel content is in his favor, whereas both the foreign material and the damage contents are not. Thus, the practice of rounding off upward is 2 to 1 against the seller.

(2) Variations in damage and sound mature kernel analyses can be attributed entirely to chance variation in the sample. These variations

can be decreased to a suitable level by employing a sample of about 2 pounds for analysis.

(3) Variation in foreign material analysis is due to variations among bucket samples, as well as a chance variation within a bucket sample. The first can be eliminated by unloading each truck and by obtaining an unbiased sample of the entire load of peanuts while reloading. The other variation can be reduced by precleaning all loads over 5 per cent foreign material and by employing a sample of about 2 pounds for analysis.

(4) The dollar variation in repeat peanut grades can be attributed to the sources of variation listed in the first three items. Thus, by reducing these variations to the recommended level, the dollar variation will be reduced to the point where "shopping around" will be neither necessary nor profitable and will thus disappear after retraining the peanut sellers.

Respectfully submitted:

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Approved:

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APPENDIX

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If certain assumptions are made about peanut sampling, the percentage of damaged kernels in repeated random samples follows a very definite mathematical pattern. It is generally accepted that the precise determination of the percentage of damaged kernels in a load of peanuts can be determined only by inspecting the entire truck load. This is obviously out of the question in pricing peanuts and so, at present, a sample of approximately 200 kernels for Runner peanuts is selected to estimate the percentage damage for the entire truck load. If we assume the following:

(1) the sample is taken in a representative fashion,

(2) the damaged kernels have the same average weight as the undamaged kernels, and

(3) the presence of a damaged kernel in one-half the peanut does not affect the probability of obtaining a damaged kernel in the other half of the peanut,

we can use the laws of mathematical probability[14] to calculate how repeated samples from the same load of peanuts will be distributed about the true percentage damaged on the truck.

Such distributions have been calculated for damage content in the load of 1, 2, 3, 5, 8, and 10 per cent. They have also been worked out for samples of 16 and 64 ounces in addition to the value of 4 ounces used at present. These values, given in Table X, show the average percentage of repeated samples that will be in error by the values listed. The table shows quite clearly the decreased variability for samples of 16 and 64 ounces. In general, quadrupling the sample size will reduce the variability by one-half. The table also shows the need for larger samples.

[14] The Bernouli Distribution is the mathematical model for this problem.

TABLE X

VARIATIONS IN REPRESENTATIVE RUNNER PEANUT SAMPLING

Sample Size (Ounces)	Per Cent Damage In Load	Number of Peanuts In Sample	Standard Deviation of Sample Per Cent Damage	Probabilities of Obtaining the Sampling Errors Listed (Per Cent)*						Method Used in Calculation
				0%	± 1%	± 2%	± 3%	More Than ± 3%	Total	
4	1	200	0.704	50.0	47.0	3.0	--	--	100.0	Bernouli
16	1	800	0.352	84.4	15.6	--	--	--	100.0	Normal t
64	1	3200	0.176	99.6	0.4	--	--	--	100.0	Normal t
4	2	200	0.992	37.5	48.9	11.9	1.2	0.5	100.0	Bernouli
16	2	800	0.496	68.6	31.2	0.2	--	--	100.0	Normal t
64	2	3200	0.248	95.6	4.4	--	--	--	100.0	Normal t
4	3	200	1.208	32.1	46.4	17.6	3.5	0.4	100.0	Normal t
16	3	800	0.604	59.2	39.5	1.3	--	--	100.0	Normal t
64	3	3200	0.302	90.2	9.8	--	--	--	100.0	Normal t
4	5	200	1.540	25.4	41.6	22.4	8.2	2.4	100.0	Normal t
16	5	800	0.770	48.5	46.4	5.0	0.1	--	100.0	Normal t
64	5	3200	0.385	80.5	19.5	--	--	--	100.0	Normal t
4	8	200	1.920	20.2	35.8	24.4	12.4	7.2	100.0	Normal t
16	8	800	0.960	39.8	48.3	10.9	1.0	--	100.0	Normal t
64	8	3200	0.480	70.2	29.6	0.2	--	--	100.0	Normal t
4	10	200	2.12	18.6	33.4	24.2	13.8	10.0	100.0	Normal t
16	10	800	1.06	36.3	48.1	13.8	1.7	0.1	100.0	Normal t
64	10	3200	0.53	65.3	34.2	0.5	--	--	100.0	Normal t

* If a truck contains 3% damaged runner peanuts, and a 4 ounce sample is used for analysis, then on the average, 32.1% of repeated samples will be correct, 46.4% will be in error by ± 1%, 17.6% by ± 2%, etc.